

Notes on the Cephalopods of Monterey Bay, California, with New Records for the Area

BY

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(4 Text figures)

INTRODUCTION

ALTHOUGH THE DISTRIBUTION and abundance of cephalopods has been studied extensively along the coast of western North America, the literature on these mollusks in Monterey Bay, California, has been brief. HOYLE (1904) and BERRY (1912a) reviewed the first extensive cephalopod collections from the Pacific coast made by the U.S. Fish Commission steamer *Albatross* and BERRY (1912a) recorded 11 species taken in Monterey Bay. SMITH & GORDON (1948) listed 15 species known from the bay at the time but added no new records of their own. Cephalopods caught chiefly by commercial fishing in the area have been reported by BARTSCH (1935), CLARK & PHILLIPS (1936), CLASSIC (1929, 1949), CROKER (1937), FIELDS (1950, 1965), PHILLIPS (1933, 1934, 1941, 1961), and SCOFIELD (1924).

More recently other authors have surveyed the pelagic cephalopod fauna of certain geographic areas of the Pacific coast. MCGOWAN (1967) and OKUTANI & MCGOWAN (1969) examined the distribution of the cephalopods in the California Current system, most of which were taken off southern California. YOUNG (1972) revised the taxonomy of the eastern Pacific pelagic cephalopod fauna based on thousands of specimens primarily from off southern California. PEARCY (1965), PEARCY *et al.* (1977) and ROPER & YOUNG (1975) have analyzed the vertical distribution of pelagic cephalopods based on midwater trawl surveys. As a result of these works, the distribution of most pelagic cephalopods now known from Monterey Bay has been updated.

The ecological and taxonomic literature on eastern North Pacific benthic octopods is sparse, but some work has appeared based on specimens caught in Monterey Bay. FISHER (1923, 1925) reported on the brooding habits of a

small subtidal species (*cf. Octopus rubescens*) caught in the bay. PHILLIPS (1934) reviewed the octopod fishery in California, much of which was then concentrated in Monterey Bay, and elaborated on each nominal species. WARREN *et al.* (1974) caught tidepool-dwelling *O. rubescens* in the bay and studied color changes. BALLERING *et al.* (1972) observed evenomation in *O. rubescens* also caught intertidally in the bay.

Despite the fact that most species known from Monterey Bay were discussed in the literature above, there has been no report on the cephalopods from the bay since SMITH & GORDON (1948). This paper reports on the cephalopods collected with closing trawls by Moss Landing Marine Laboratories (MLML) and Steinhart Aquarium, San Francisco (MCCOSKER & ANDERSON, 1976), provides information on the vertical distribution of some species that occur in Monterey Bay and increases the number of species known from this area.

MATERIALS AND METHODS

Most specimens of pelagic cephalopods detailed in this study were taken from the bay during the bimonthly Steinhart Aquarium Midwater Maintenance Program (SAMMP) cruises with a modified, 1.8 m Tucker trawl (TUCKER, 1951). The 9 mm mesh net was outfitted with a messenger operated, double-release mechanism and a flow-through, canvas cod end bag (see BAKER *et al.*, 1973). The net was towed at about two knots from the R/V *ST-908*, a 16.5 m converted harbor tug on loan to MLML from Scripps Institution of Oceanography. Two to four one hour hauls per cruise resulted in 56 discrete depth samples grouped in 100 m intervals from the surface to 800 m. Additional specimens were obtained from seven ½ hour hauls in the upper 100 m. Tow depth was determined by reading

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the disc charts from a Benthos Time-Depth Recorder, model 1170. A total of 151 specimens of pelagic cephalopods was thus collected from two areas in Monterey Canyon between 27 August 1974 and 23 January 1976 (Figure 1).

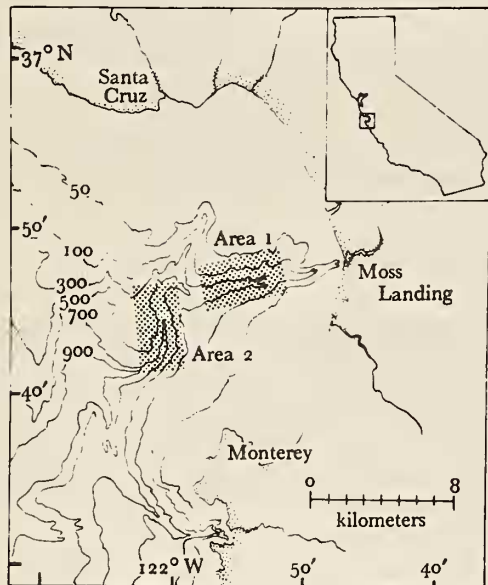


Figure 1

Map of Monterey Bay, California, showing the SAMMP trawling areas. Contours in fathoms

In addition to the above samples, two cruises of the USNS *De Steiguer* resulted in nine successful hauls with a 2.2 m beam trawl on the lower continental slope off Monterey Bay and in the canyon. Two new benthic octopods were taken by a party of MLML students.

Specimens were fixed in 10% formalin for several days, rinsed in water and stored in 70% ethanol. All specimens reported here as new to the area have been deposited in the collection of the Department of Invertebrate Zoology, California Academy of Sciences, San Francisco, or the Museum of Moss Landing Marine Laboratories. Identifications of pelagic specimens were made utilizing the key in YOUNG (1972). In all cases the dorsal mantle length (DML) was measured as an indication of body size. All measurements are in millimeters (mm) unless otherwise indicated. The vertical distribution of the two most abundant pelagic cephalopods (young of *Gonatus onyx* and *Galiteuthis phyllura*) was calculated on a catch per unit effort basis by plot-

ting the average number taken per hour of trawling in each 100 m interval divided by the total number of tows, 63.

FAMILY ACCOUNTS

The species of cephalopods presently known from Monterey Bay are discussed below. Ten species have not been reported previously from the bay: *Gonatus onyx* (BERRY's, 1912a, records of *G. fabricii* probably are this species, at least in part), *Gonatus californiensis*, *Gonatopsis borealis*, *Berryteuthis anonychus*, *Chiroteuthis calyx*, *Octopoteuthis deletron*, *Valbyteuthis danae*, *Japetella heathi*, *Granelledone* sp. and *Benthoctopus* sp. New data, chiefly regarding the recent occurrences are presented below. The relative abundances of cephalopods from the 63 closing net samples are given in Figure 2. For most species, only the

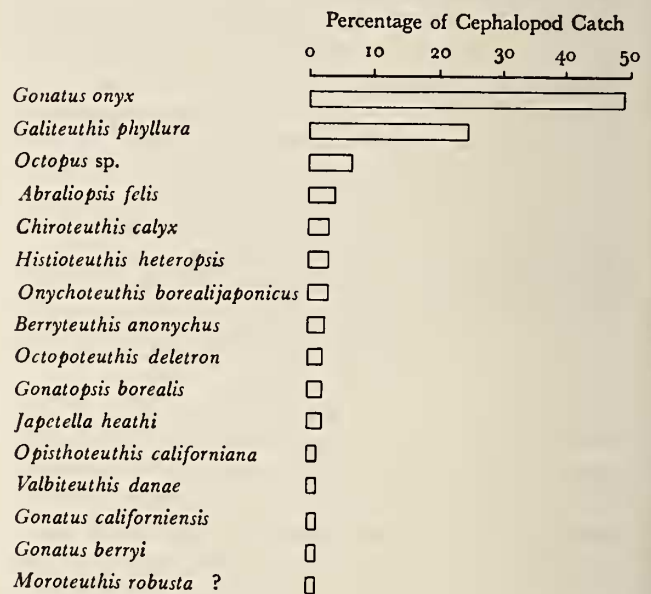


Figure 2

Percent composition of pelagic cephalopods in the SAMMP mid-water trawl catches; N = 63 samples

young are represented and exact populational abundances are not known due to probable net avoidance of larger individuals, especially during the day.

SEPIOIDEA

SEPIOLIDAE

Rossia pacifica Berry, 1911

The common benthic sepiolid, *Rossia pacifica* often is taken in bottom trawls between about 40 and 250 m in the bay. Over twenty specimens have been taken by MLML in recent years and it appears to be absent over coarse sand, preferring instead muddy bottoms.

TEUTHOIDEA

LOLIGINIDAE

Loligo opalescens Berry, 1911

Loligo opalescens is the only commercially fished cephalopod in Monterey Bay today; over 7,000 tons were landed at the bay's 3 ports in 1974 (McALLISTER, 1976). Fishing grounds stretch from south of the Salinas River to west of Monterey in depths of about 20 to 50 m. This is also the chief spawning area for the species. FIELDS (1965) detailed the general biology of *L. opalescens* and a recent symposium held at the annual California Cooperative Oceanic Fisheries Investigations (CalCOFI) meetings has updated our knowledge of this cephalopod, the results of which are to be published in the CalCOFI Reports. The reader is referred to this publication for most of the literature on *L. opalescens*.

ENOPLOTEUTHIDAE

Abraliopsis felis McGowan & Okutani, 1968

Only eight specimens of *Abraliopsis felis* (8-38 mm DML), a relatively abundant offshore squid (OKUTANI & MCGOWAN, 1969), were taken during the SAMMP program inside the bay. It is one of the most frequently encountered prey species of albacore caught off central California, but its appearance in Monterey Bay probably is occasional. Because of changes in length frequencies, PEARCY (1965) suggested the species may be a seasonal breeder in near-shore waters off Oregon during the summer.

OMMASTREPHIDAE

Dosidicus gigas d'Orbigny, 1835

The jumbo squid, *Dosidicus gigas*, enters Monterey Bay infrequently (BARTSCH, 1935; CLARK & PHILLIPS, 1936;

CROKER, 1937; PHILLIPS, 1933). Clark and Phillips listed the northernmost capture locality for this species as 20 miles north of Santa Cruz, which apparently is still valid. Known to attain 1.5 m DML off Peru (see WORMUTH, 1974), Monterey Bay specimens have generally measured less than about 350 mm DML (CLARK & PHILLIPS, 1936; personal observations of five specimens taken in 1974 and 1976).

HISTIOTEUTHIDAE

Histioteuthis heteropsis (Berry, 1913)

Although infrequently encountered above 500 m in Monterey Bay, ten specimens of *Histioteuthis heteropsis* (12-128 mm DML) have been captured recently. Five mid-water trawl collections were below 400 m during the day, one in 300 m at night captured two specimens. One specimen (76 mm DML) was found dead on the beach in front of MLML after strong winds in March, 1975. Generally voracious in the aquarium, specimens have lived a maximum of four days at 7°C (MCCOSKER & ANDERSON, 1976).

OCTOPOTEUTHIDAE

Octopoteuthis deletron Young, 1972

Two specimens of *Octopoteuthis deletron* (24, 102 mm DML) were taken in the closing midwater trawl at 190 and 500 m, both during the day. In addition to these, 1 specimen was identified from the stomach of the slope-dwelling fish *Antimora microlepis* captured in a beam trawl in 1390 m, suggesting the squid was swimming close to the sea floor. The fish is not known to swim far off the bottom in search of prey.

GONATIDAE

Berryteuthis anonychus (Pearcy & Voss, 1963)

The Gonatidae are one of the most abundant oegopsid squid families in California waters. Two specimens of *Berryteuthis anonychus* (26, 72 mm DML) were captured in the midwater trawl fished between 400 and 500 m at night. This record adds another gonatid to these waters and extends the known range of *B. anonychus* southward from Oregon, the only other reported capture locality (PEARCY & VOSS, 1963; YOUNG, 1972).

Gonatus californiensis Young, 1972

Published eastern North Pacific ranges of *Gonatus* species are from northern Baja California to off Oregon

(YOUNG, 1972; PEARCY *et al.*, 1977). A single specimen of *Gonatus californiensis* (15 mm DML) was taken in the same haul as the *Berryteuthis* specimens, and represents the northernmost record for this species. Also, a single

Gonatus berryi Naef, 1923

specimen of *Gonatus berryi* (20 mm DML) was taken in the midwater trawl between 400 and 500 m at night. Another *G. berryi* was taken in a zooplankton tow fished to 200 m at night but subsequently was lost.

Gonatus onyx Young, 1972

Larval and juvenile *Gonatus onyx* were the most abundant pelagic cephalopod taken in midwater trawls in Monterey Bay (72 specimens, 8-53 mm DML). An upward shift at night for these young was evident (Figure 3). Three spec-

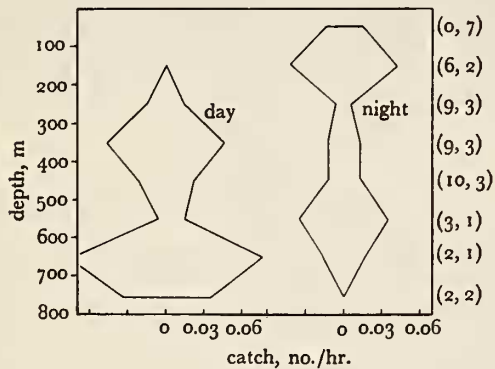


Figure 3

Vertical distribution of *Gonatus onyx* in Monterey Canyon. Catch per effort mirrored. Numbers in parentheses on right are sample sizes in each 100 m interval, day first, then night

imens (42-45 mm DML) were dip-netted at the surface one night. Although hauls below 500 m were scarce, an increase in number occurred around 600 to 700 m during the day, possibly due to a near-bottom concentration of nekton and plankton noted for some fish and crustaceans as well (ANDERSON, 1977). ROPER & YOUNG (1975), by using a correction factor to compensate for unequal trawling time at depth, show the daytime center of abundance of the species in southern California waters to be around 600 m. PEARCY *et al.* (1977), however, show a daytime center at about 300

m off Oregon with small individuals clustered in the upper 100 m. LU & CLARKE (1975) suggest a pattern of ontogenetic descent (larvae descend as they grow) in *G. fabricii* which, if applied to *G. onyx* in Monterey Bay, would mean the proposed vertical migration in this species is a compounded result of different distributional patterns.

Gonatopsis borealis Sasaki, 1923

Two young *Gonatopsis borealis* (22, 26 mm DML), a species ranging from California to the Bering Sea and Japan, were taken in the same midwater trawl haul as the *Berryteuthis* specimens in 400 to 500 m at night. In addition, two large adults (229, 185 mm DML) were taken in a commercial trawl operated by the National Marine Fisheries Service off Santa Cruz in August, 1976. This daytime collection in nearshore waters of 220 to 250 m depth probably is unusual, unless adults occupy shallower water than juveniles. PEARCY *et al.* (1977) found the daytime distribution of young *Gonatopsis* in oceanic waters off Oregon to be between 200 and 600 m. Similarly, ROPER & YOUNG (1975) found the daytime center of distribution off southern California to be about 400 to 600 m for this species.

ONYCHOTEUTHIDAE

Moroteuthis robusta Verrill, 1876

Five records of the giant squid, *Moroteuthis robusta*, exist from Monterey Bay (BERRY, 1912b, 1914; PHILLIPS, 1933, 1961; SMITH, 1963). HOCHBERG (1974) reported some recent captures from southern California and SMITH (1963) and TALMADGE (1967) have reported captures from northern California. One larval specimen (26 mm DML) that is tentatively referred to this species (R. E. Young, pers. comm.) was taken in the midwater trawl fished at night in 400 to 500 m. Additionally, an immature female 710 mm DML) was found floating dead at the surface by MLML divers about one mile off Moss Landing. Apparently, the species is abundant in about 200 to 400 m, particularly during the fall.

Onychoteuthis borealijaponicus

Okada, 1927

Onychoteuthis borealijaponicus is represented in the collection by four larvae (9-16 mm DML) taken at night in 400 to 500 m. Adults periodically are common at the surface just outside the bay and often are taken by local fishermen for bait.

CHIROTEUTHIDAE

Chiroteuthis calyx Young, 1972

Six specimens of *Chiroteuthis calyx* (26-52 mm DML) were taken in the midwater trawl fished between 300 and 700 m. Other cruises have yielded additional specimens bringing the present total to 21, and the species apparently is abundant year-round. All specimens are "doratopsis" larvae or young juveniles less than 70 mm DML. One larva (31 mm DML) was dip-netted at the surface at night.

Valbyteuthis danae Joubin, 1931

A single specimen of *Valbyteuthis danae* (55 mm DML) was caught in the midwater trawl at night in 400 to 500 m. YOUNG (1972) also reported a single specimen from off southern California and concluded his specimen was a straggler from a more tropical population, since previously it was known only from Panama and Peru. CLARKE & LU (1974) suggested ontogenetic descent in this species, and indeed YOUNG (1972) described it as one of the deepest living cephalopods off southern California. This second California specimen suggests the species is more widely distributed than current data indicate.

CRANCHIIDAE

Galiteuthis phyllura Berry, 1911

Larval and juvenile *Galiteuthis phyllura* were the second most abundant cephalopod sampled by midwater trawl (36 specimens, 6-68 mm DML). A slight upward shift at night was detected for these specimens and the species was absent from the upper 100 m (Figure 4). ROPER & YOUNG (1975)

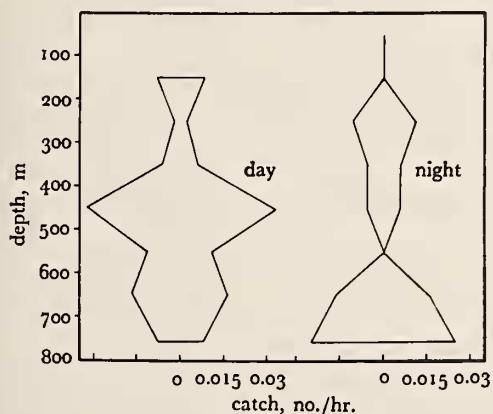


Figure 4

Vertical distribution of *Galiteuthis phyllura* in Monterey Canyon. Graphics after Figure 3

show ontogenetic descent in larval *Galiteuthis*. Only five specimens larger than 60 mm DML (larval development complete) were taken in the bay and these were from night tows between 300 and 600 m.

VAMPYROMORPHA

VAMPYROTEUTHIDAE

Vampyroteuthis infernalis Chun, 1903

A single young specimen of the vampire squid, *Vampyroteuthis infernalis* (13 mm DML) was taken in an open midwater trawl that fished to 1000 m by personnel of Hopkins Marine Station, Pacific Grove. An inhabitant of great depths, it is likely that more specimens will be taken in the bay as deeper hauls are made, since it is considered a worldwide species (PICKFORD, 1946).

PHILLIPS (1934) reported a specimen of *Cirrosteuthis macrope* Berry, 1911 from the bay but this nominal species should be referred to the synonymy of *Vampyroteuthis infernalis* Chun, 1903 (YOUNG, 1972). It is not known if Phillips' specimen was a vampire squid or a cirrate octopod such as *Opisthoteuthis californiana* which it resembles. The specimen could not be found and may not have been preserved.

OCTOPODA

BOLITAENIDAE

Japetella heathi (Berry, 1911)

Two young specimens of *Japetella heathi* (13, 27 mm DML) were taken by the closing trawl in daytime tows between 300 and 600 m. Two other specimens (17, 21 mm DML) were taken in open nets fished to over 500 m during the day. YOUNG (1972) indicated some taxonomic confusion exists in *Japetella* and the Monterey Bay specimens have been tentatively identified to *J. heathi* due to the presence of silvery tissue around the eyes.

ARGONAUTIDAE

Argonauta pacifica Dall, 1872

The tropical-subtropical paper nautilus, *Argonauta pacifica* has been found off California, apparently more often during warm water years of the nineteenth century. DALL (1872: 95) first reported it, "so common at certain periods on the coast of California . . ." and later listed it from Mon-

terey Bay (DALL, 1908). Apparently, it has not been collected subsequently in the bay.

OCTOPODIDAE

Graneledone sp.

Four specimens of the slope-dwelling octopod, *Graneledone* sp., recently were taken off Monterey Bay. One, from a commercial sablefish trap set in 1165 m, measured 156 mm DML. Three others (100, 108, 121 mm DML) were taken in a beam trawl at depths of 1336 to 1409 m. During

Benthoctopus sp.

the same cruises, 4 specimens of *Benthoctopus* sp. (34, 35, 41, 50 mm DML) were caught in hauls made between 1336 and 1609 m. Neither species has been positively identified and they may be new to science (W. G. Pearcy, pers. comm.).

Octopus californicus Berry, 1911 ?

Octopus dofleini (Wülker 1910)

Octopus leioderma Berry, 1913

Octopus pricei Berry, 1913

Octopus rubescens Berry, 1953

Three species of *Octopus* are known to me from recent collections in the bay: *O. rubescens*, *O. dofleini* and *O. leioderma*. BERRY (1911, 1912a) listed a young *O. californicus* from deep water off Monterey Bay but cautioned that its identity was not certain. *Octopus pricei* was described from Monterey Bay (BERRY, 1913), but no individuals positively referable to this species have been identified recently. *O. rubescens* is the commonest intertidal-subtidal octopod in Monterey Bay (see WARREN *et al.*, 1974; BALLERING *et al.*, 1972) and it has been taken to a depth of 267 m. Below that depth *O. californicus* should occur, but collections from the canyon at depths greater than 200 m are few and specimens have not been obtained as yet. PHILLIPS (1934) reported *Polypus hongkongensis* as the common subtidal octopod that composed most of the California fishery. PICKFORD (1964), however, showed *P. hongkongensis* Berry, 1911 to be a synonym of *Octopus dofleini* (Wülker, 1910), a widely distributed, variable species. Additionally, a recent otter trawl collection in the bay yielded 2 specimens of *Octopus leioderma* (45, 55 mm DML) from 110 to 149 m depth.

OPISTHOTEUTHIDAE

Opisthoteuthis californiana Berry,

1949

A single, bright orange juvenile of the benthopelagic octopod *Opisthoteuthis californiana* (21 mm DML) was taken in the midwater trawl at a depth of 350 to 460 m (between 120 and 260 m above the bottom) during the day. This specimen lived for 5 days in the Steinhart Aquarium cold water tank at MLML (see McCOSKER & ANDERSON, 1976). The octopod exhibited positive phototaxis (in dull light) and swam in short bursts by rapidly pulsing its webbed arms, augmented by siphonal jet propulsion. The fins were flapped alternately to maintain a vertical position in the water column in the manner reported by PEREYRA (1965).

DISCUSSION

Although the collection of pelagic cephalopods reported here lacks a total size range for all species and, in fact, represents only a few specimens of each, it is the largest series of its kind collected so far from Monterey Bay. To emphasize the prior lack of knowledge of cephalopods from this area, it should be noted that a single haul of the Tucker trawl one night yielded 5 species never reported before from the bay.

To examine seasonal variation in the pelagic cephalopod catch, numbers of species and individuals of cephalopods were compared to numbers of species and volumes of all micronekton (fishes, shrimp and squid) and plotted against time. The result was that cephalopod abundance remained almost constant due to the numerical dominance of *Gonatus onyx* and *Galiteuthis phyllura*. A one way analysis of variance with unequal sample size (SOKAL & ROHLF, 1969) showed that variability in micronekton volumes was so high within seasonal categories that differences were not statistically detectable. This was thought to be due to small sample size, variability in depths sampled and the rather weakly defined hydrographic seasons in Monterey Bay during the trawling (BROENKOW *et al.*, 1975, 1976).

However, PEARCY (1976) recorded an increase of nekton and plankton in the winter in nearshore areas off Oregon. Similarly, FAST (1960) showed a winter "invasion" of juvenile lanternfish, *Stenobrachius leucopsarus* in Monterey Bay and hypothesized that at this time of year the canyon may act as a concentrating basin in conjunction with the nearshore component of the northward flowing Davidson

Current. At this time, the effect of nearshore submarine canyons on the concentration of nekton and plankton is unproven and clearly more study is needed in this area.

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